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(54) **An antenna interconnection pattern**

(57) The invention relates to an antenna interconnection pattern for converting radio frequency energy to direct current energy. The pattern comprises an input port for connecting to an antenna and an additional input port for connecting to an additional antenna. Both, the input port and the additional input port are connected to a common antenna output port via transmission line branches. Each transmission line branch comprises an intermedi-

ate point and an transmission line end section connecting the respective intermediate points to the common direct current output port. Further, each transmission line end section represents a multiplicity factor times a wavelength of incoming radio waves that are received by the antennas during use of the pattern, wherein the multiplicity factor is approximately a natural number plus a quarter, and wherein the intermediate points are further interconnected via a diode circuitry.

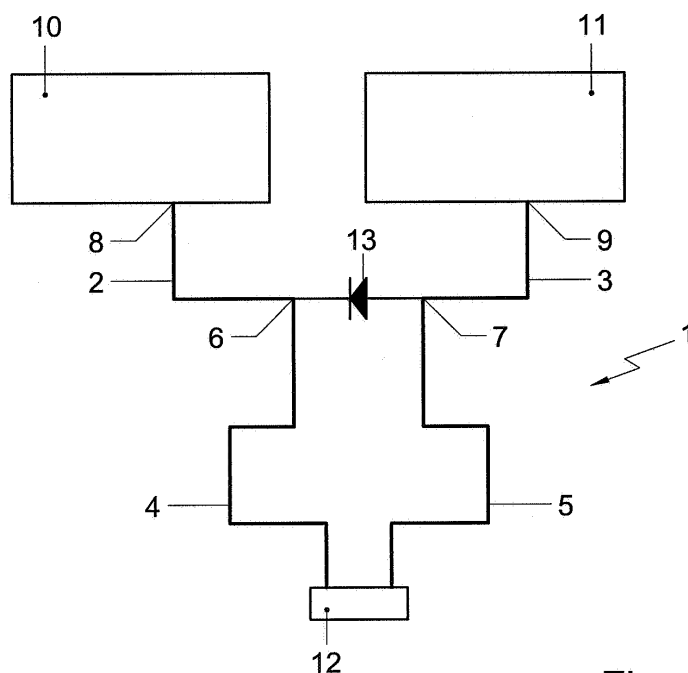


Fig. 1

Description

[0001] The invention relates to an antenna interconnection pattern for converting radio frequency energy to direct current energy.

[0002] A so-called rectenna is known wherein such an antenna interconnection pattern is provided with a rectifier, thereby reducing the need for local energy suppliers, such as batteries.

[0003] However, an antenna that is connected to a rectifier cannot be used for communication purposes.

[0004] It is an object of the invention to provide an antenna interconnection pattern according to the preamble, wherein the disadvantage identified above is reduced. In particular, the invention aims at obtaining an antenna interconnection pattern according to the preamble wherein an antenna that is connected to the antenna interconnection pattern according to the invention can be used for both providing direct current energy and wireless communicating. Thereto, according to the invention, the antenna interconnection pattern comprises an input port for connecting to an antenna and further comprises an additional input port for connecting to an additional antenna, the input port and the additional input port each being connected to a common direct current output port via transmission line branches, each transmission line branch comprising an intermediate point and a transmission line end section connecting the respective intermediate points to the common antenna output port, each transmission line end section representing a multiplicity factor times a wavelength of incoming radio waves that are received by the antennas during use of the pattern, wherein the multiplicity factor is approximately a natural number plus a quarter, and wherein the intermediate points are further interconnected via a diode circuitry.

[0005] It is noted that the transmission line structure interconnecting the input port, the additional input port and the direct current output port is known as a Wilkinson power divider circuitry for providing n ports with a voltage of equal phase and equal amplitude. The Wilkinson power divider circuitry is disclosed in more detail in "An N-Way Hybrid Power Divider" by E.J. Wilkinson in IEE Transactions on microwave theory and techniques, 2006, page 116 sqq.

[0006] In the pattern according to the invention, a Wilkinson power divider circuitry is applied wherein an internal load resistor interconnecting the intermediate points of the transmission line end sections is replaced by the diode circuitry.

[0007] By applying the Wilkinson power divider circuitry with an diode circuitry between the intermediate points an antenna interconnection pattern is obtained providing both direct current power retrieval and wireless communication features. The invention is partly based on the insight that by retrieving direct current energy via a proper intermediate network, communication functions of the antenna can remain intact.

[0008] Due to properties of the Wilkinson power divider

circuitry, retrieval of direct current energy can be performed especially for radio waves having frequencies for which the antennas are not properly terminated. However, also in the case that radio waves are intercepted in a frequency band for which the antennas have been designed, at least some direct current energy can be retrieved as according to network theory a three-port can merely be matched resistively.

[0009] The antenna interconnection pattern according to the invention can advantageously be used for mobile communication devices, especially in low power wireless communication applications with reduced power sources, or in applications wherein the use of local power sources is even undesired or impossible. Examples of low power wireless communication applications are devices for local area networks.

[0010] In a preferred embodiment, the transmission line branches are implemented using micro strip technology, so that a simple, cheap and compact implementation of the transmission lines is obtained. A planar technology might be applied, however circular transmission line technology is of course also applicable, such as coax cable elements.

[0011] Other advantageous embodiments according to the invention are described in the following claims.

[0012] By way of example only, embodiments of the present invention will now be described with reference to the accompanying figures in which

Fig. 1 shows a circuitry of a first embodiment of an antenna interconnection pattern according to the invention, and

Fig. 2 shows a circuitry of a second embodiment of an antenna interconnection pattern according to the invention.

[0013] The figures are merely circuitries of preferred embodiments according to the invention. In the figures, the same reference numbers refer to equal or corresponding parts.

[0014] Figure 1 shows a circuitry 1 of a first embodiment of an antenna interconnection pattern according to the invention.

[0015] The circuitry 1 comprises two transmission line branches, each comprising a first section 2, 3 and an end section 4, 5. Each first section 2, 3 and end section 4, 5 is interconnected at an interconnection point 6, 7. Further, the first sections 2, 3 are connection to an input port 8 and an additional input port 9, respectively, that are electrically connected to an antenna and an additional antenna. Both antennas are implemented as micro strip patch antennas 10, 11. The end sections 4, 5 of the branches end in a common direct current output port 12 for retrieval of a communication signal.

[0016] According to the invention, each transmission line end section represents a multiplicity factor times a wavelength of incoming radio waves that are received by the antennas during use of the pattern. The multiplicity

factor is approximately a natural number plus a quarter to guarantee Wilkinson power divider circuitry properties, viz. cancellation of reflected waves.

[0017] The transmission line branches are realized using micro strip technology. In doing so, a ground plate of a printed circuit board serves as the earth, while on the opposite side of the board an electrically conducting pattern is printed. The printed circuit board has dielectric properties to electromagnetically couple the printed pattern and the ground plate. In particular, the transmission line branches 2, 3, 4, 5 are formed as printed tracks, while the antenna patches are realized as rectangular plane sections that are designated for optimal receipt and transmission of e.g. 2.45 GHz. It is noted, however, that also other techniques could be used, such as etching techniques for forming the structures on the printed circuit board.

[0018] The intermediate points 6, 7 of the transmission line branches form output ports of the antennas for retrieval of direct current energy. The energy can be fed to local energy buffers, such as a capacitor or a rechargeable battery.

[0019] Further, the interconnection points 6, 7 are connected to each other via a diode structure, implemented as a single diode component 13. In Figure 2, a circuitry of a second embodiment according to the invention is shown, wherein the diode structure is implemented as two anti-parallel placed diode 14, 15 components for improved gain of the direct current energy.

[0020] The single or two anti-parallel placed diodes 13, 14, 15 might be connected to the intermediate points 6, 7 using several techniques, such as soldering, gluing or otherwise to obtain an electrical conducting connection.

[0021] Further, a more complex diode structure can be employed to further enhance a direct current energy retrieval from the received radio waves.

[0022] The invention is not restricted to the embodiments described herein. It will be understood that many variants are possible.

[0023] As an example, geometries of the antenna patches can also be designed for performing wireless communication using radio waves having other frequencies, e.g. more or less than 2.45 GHz.

[0024] In addition, multiple antenna interconnecting pattern connected to pairs of antennas can be used for improving a direct current energy retrieval gain.

[0025] Other such variants will be obvious for the person skilled in the art and are considered to lie within the scope of the invention as formulated in the following claims.

ditional antenna, the input port and the additional input port each being connected to a common antenna output port via transmission line branches, each transmission line branch comprising an intermediate point and an transmission line end section connecting the respective intermediate points to the common direct current output port, each transmission line end section representing a multiplicity factor times a wavelength of incoming radio waves that are received by the antennas during use of the pattern, wherein the multiplicity factor is approximately a natural number plus a quarter, and wherein the intermediate points are further interconnected via a diode circuitry.

2. An antenna interconnection pattern according to claim 1, wherein the diode circuitry comprises a single diode component.
3. An antenna interconnection pattern according to claim 1, wherein the diode circuitry comprises two anti-parallel placed diode components.
4. An antenna interconnection pattern according to any of the previous claims, wherein the transmission line branches are implemented using micro strip technology.
5. An antenna interconnection pattern according to any of the previous claims, further comprising a pair of micro strip patch antennas, each connected to an input port of the pattern.

Claims

1. An antenna interconnection pattern for converting radio frequency energy to direct current energy, comprising an input port for connecting to an antenna, an additional input port for connecting to an ad-

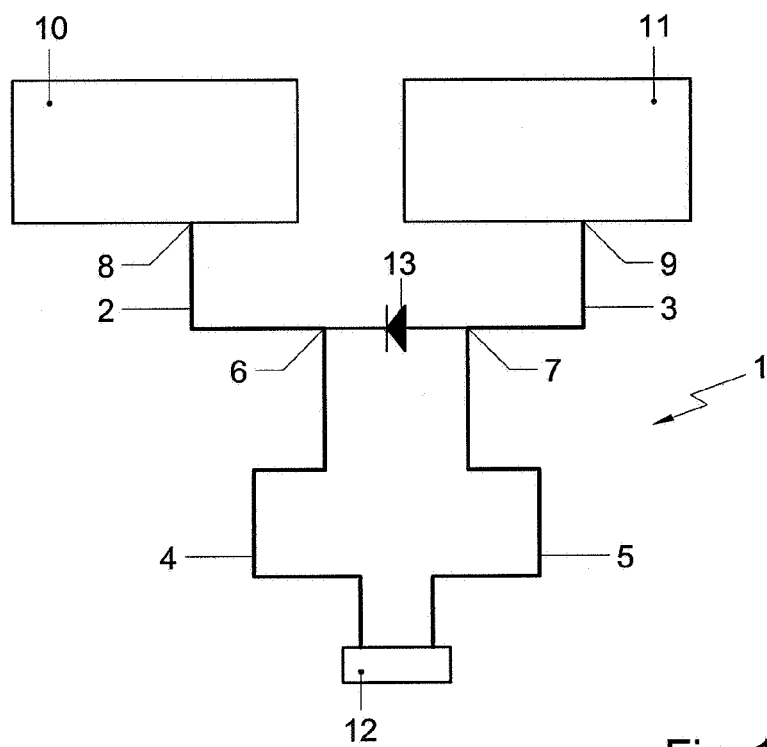


Fig. 1

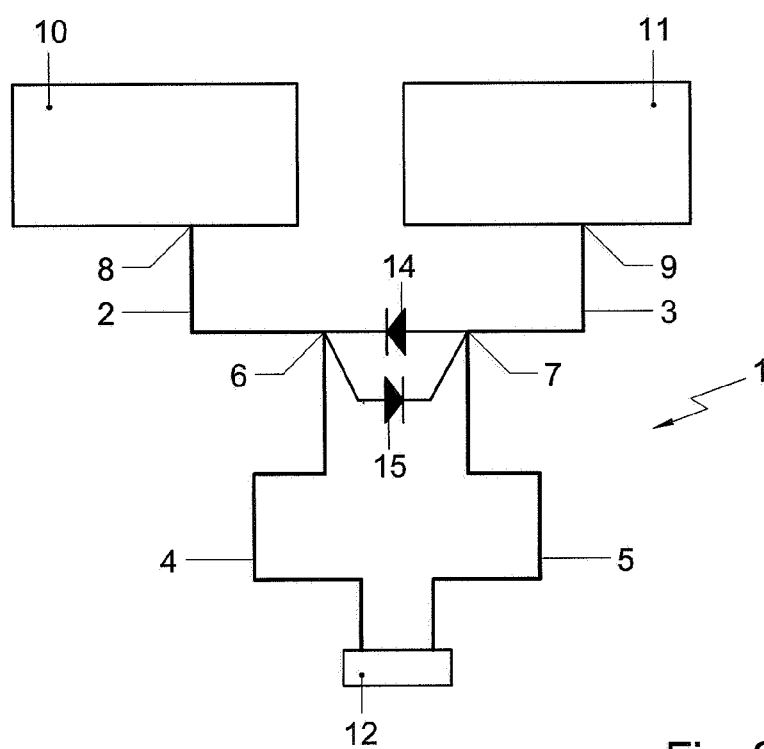


Fig. 2



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 07 10 3005

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 530 637 A (FUJITA SUGURU [JP] ET AL) 25 June 1996 (1996-06-25) * abstract; figures 1,3,4,14 * * column 6, lines 15-33 * * column 7, line 46 - column 8, line 41 * -----	1,2,4,5	INV. H01Q1/24 H01Q21/29
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			TECHNICAL FIELDS SEARCHED (IPC)
			H01Q
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 2 August 2007	Examiner CORDEIRO, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 07 10 3005

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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02-08-2007

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- **E.J. WILKINSON.** An N-Way Hybrid Power Divider.
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